

Heterodera elachista n. sp., an upland rice cyst
nematode from Japan

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Morphology of a cyst-forming species attacking roots of upland rice in Japan which had been referred to *Heterodera oryzae* Luc *et* Brizuela, 1961, was studied, and *Heterodera elachista* n. sp. was described. This species is most closely related to *H. salixophila* Kirjanova, 1969, but can be differentiated from the latter by shorter stylet of adult female as well as the second-stage larva. This species also resembles to *H. oryzae*, *H. sacchari* Luc *et* Merny, 1963 and *H. leuceilyma* Di Edwardo *et* Perry, 1964, in the second stage larvae bearing 3 lateral lines, but differs from these species in possessing the thin underbridge without finger-like projections of cyst cone. *Jap. J. Nematol.* 4:51-56 (1974)

The first record on the morphology of *Heterodera* cysts found in the chlorotic, stunted and poorly tillered upland rice fields was made by Okada in 1953 at Tochigi, Japan.^{5,6)} This nematode species has been widely discovered from Tohoku to Kyushu districts mainly on upland rice.¹⁾ Watanabe *et al.* has proved that the major factor which commonly causes the continuous-cropping failure of upland rice is this nematode, based on a series of experiments conducted for nearly ten years since 1950.⁷⁾

Luc and Brizuela reported *Heterodera oryzae* in 1961 on the lowland temperate rice from Ivory Coast, describing for the first time that the second-stage larva bears three lateral lines.³⁾ Since the morphological characteristics of the Japanese specimen agreed mostly with those described by these authors, and also due to the fact that both nematodes have a common host plant, the Japanese rice-attacking *Heterodera* has been referred to *H. oryzae*.

Recently, Mulvey (1972) compared the structures of the cyst terminal and cone top among as many as 53 described species of *Heterodera*,

and revealed more detailed morphology of *H. oryzae* cyst.⁴⁾ From these background, the author studied the morphology of the cyst nematode collected from the upland rice fields, and noticed that this is a new species as described below under the name of *H. elachista*.

Female

Measurements of mature females in glycerine: L (excluding neck) (n=35): 330-560 (406 ± 10.1) μ , breadth (n=35): 250-450 (315 ± 9.1) μ , neck (n=32): 65-140 (89 ± 3.3) μ , stylet (n=19): 19-23 (21.3 ± 0.3) μ , opening of dorsal esophageal gland duct from stylet base (n=12): 4-5 (4.4 ± 0.1) μ . Measurements of holotype female: L=470 μ , breadth=400 μ , neck=90 μ , corpus=29 \times 26 μ , anus to vulva (shortest distance)=44 μ , valve plates 8 μ long, 6 μ wide.

Mature females and cysts ovoid, with prominent terminal cone and well-defined neck sometimes inclined at an angle to the axis of the body. Ratio of length to breadth of body about 1.3. Pattern of cuticle an angular network of ridges with parallel arrangement in the neck region (Fig. 2, I). Excretory pore located on the shoulder portion where body begins to enlarge behind neck, 75-145 ($119 \mu \pm 4.6$) μ (n=19) from anterior end. Cuticle 8-18 μ thick on body, 4-8 μ on neck and abruptly thinner (0.5 μ)

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forward from a point opposite middle of stylet.

Head distinctly offset with a six lobed circumoral head cap and a single prominent disk-shaped annule. Amphid openings, seen only in dorso-ventral view, between cap and this annule (Fig. 2, D). Anterior cephalids close behind head.

Mature females with sub-crystalline layer that easily detached when the body wall tough and brown. Older females filled with eggs : gelatinous egg-sac observed with eggs.

Esophagus and reproductive organs typical in the genus. Procorpus constricted at its junction with measurement of $24-32 (28\mu \pm 0.6)\mu$ ($n=14$) by $24-32 (27 \pm 0.5)\mu$, almost spherical. The valve plate $8-9 (8.3\mu \pm 0.1)\mu$ ($n=14$) by $6-7 (6.3 \pm 0.1)\mu$. Vulva located terminal and anus $34-48 (40.7\mu \pm 0.8)\mu$ ($n=18$) from terminal. Well-developed stylet knobs directing backwards, sometimes forwards.

Cysts

Measurements of ten specimens : fenestral length: $25-37 (28.5)\mu$, fenestral width : $25-37 (29.8)\mu$, semi-fenestral length : $9-17 (11.6)\mu$, vulval slit : $30-43 (36)\mu$, underbridge length : $75-90 (78.3)\mu$, underbridge width : $8-12 (8.9)\mu$, anus to fenestra distance : $20-30 (24.8)\mu$, anus to vulval slit : $30-46 (39.4)\mu$.

Cysts light to dark brown, lemon-shaped, ambifenestra low and rounded, about as wide as long. Medium-sized underbridge with peripheral bullae in the cone top, and without finger-like projections. (Fig. 2, G)

Eggs ($n=100$)

100 embryonated eggs from cysts : length : $78-102 (90 \pm 5.9)\mu$, breadth: $35-39 (36 \pm 1.4)\mu$, length to breadth ratio: $2.1-2.8 (2.5 \pm 0.1)$. Larva folded four times within the egg-shell.

Larvae ($n=25$)

L: $330-405 (367 \pm 16.8)\mu$ ($n=100$), breadth: $15.5-18 (16.6)\mu$, a: $20.3-24.1 (22.6)$, anterior end to junction of esophagus and intestine: $84-97 (88.8)\mu$, b: $4.0-4.6 (4.2)$, anterior end to centre of median bulb : $52-60 (56.4)\mu$, bm (= total body length / distance from anterior end to valve

plates in median esophageal bulb): $6.1-7.2 (6.7)$, anterior end to end of esophageal glands : $120-155 (137.7)\mu$, b': $2.4-3.3 (2.7)$, anterior end to excretory pore: $74-85 (81.1)\mu$, X (=distance of excretory pore from anterior end $\times 100$ / total body length): $20.5-22.4 (21.6)$, tail: $44-57 (52.7)\mu$, c: $6.7-8.1 (7.2)$, body width at anus: $9-11 (10.4)\mu$, c': $4.5-6 (5.1)$, length of hyaline tail tip: $26-36 (31.4)\mu$, stylet: $18-19.5 (18.6)\mu$, h (= hyaline tail tip / stylet length) : $1.4-1.9 (1.7)$, opening of dorsal gland duct from stylet base : $4.5-6 (5.4)\mu$ ($n=19$), O : $25-33.3 (29.2)$ ($n=19$), length of anterior part of stylet: $8-9.5 (8.4)\mu$, M : $43.2-48.7 (45.3)$, head width : $7.2-8 (7.7)\mu$ ($n=22$), head height : $3.0-3.6 (3.3)\mu$ ($n=22$), anterior end to gonadal primordium : $192-223 (204.6)\mu$, g (=distance of gonadal primordium from anterior end $\times 100$ / total body length): $51.6-57.2 (54.5)$.

Body slightly curved ventrally when killed by gentle heat. Offset head hemispherical, with four annules. Lateral field about $1/4$ body width with three incisures, starting at stylet base level and ending mid-way along the tail; outer bands aerolated. Phasmids 5-7 annules behind anus. Stylet well-developed with anteriorly concaved knobs. Esophageal gland lobe overlying intestine latero-ventrally for a distance equal to about 37% of body length. Hemizonid distinct, 2-3 annules ($2-3\mu$) long and located one annule anterior to excretory pore. Anterior cephalids at second or third, and posterior cephalids at level of six to eight neck annules. Gonadal primordium consisting of two cells, situated at about 55% of the body length from anterior end (Fig. 1, C).

Male

Measurements: L ($n=21$): $820-940 (858)\mu$, body width ($n=21$): $21-24 (22.5)\mu$, a: $35.2-40.9 (38.1)$, anterior end to junction of esophagus and intestine ($n=17$): $90-124 (110)\mu$, b: $6.9-9.1 (7.7)$, anterior end to center of median bulb ($n=21$): $72-86 (78.9)\mu$, bm (=total body length / distance from anterior end to valve plates in median

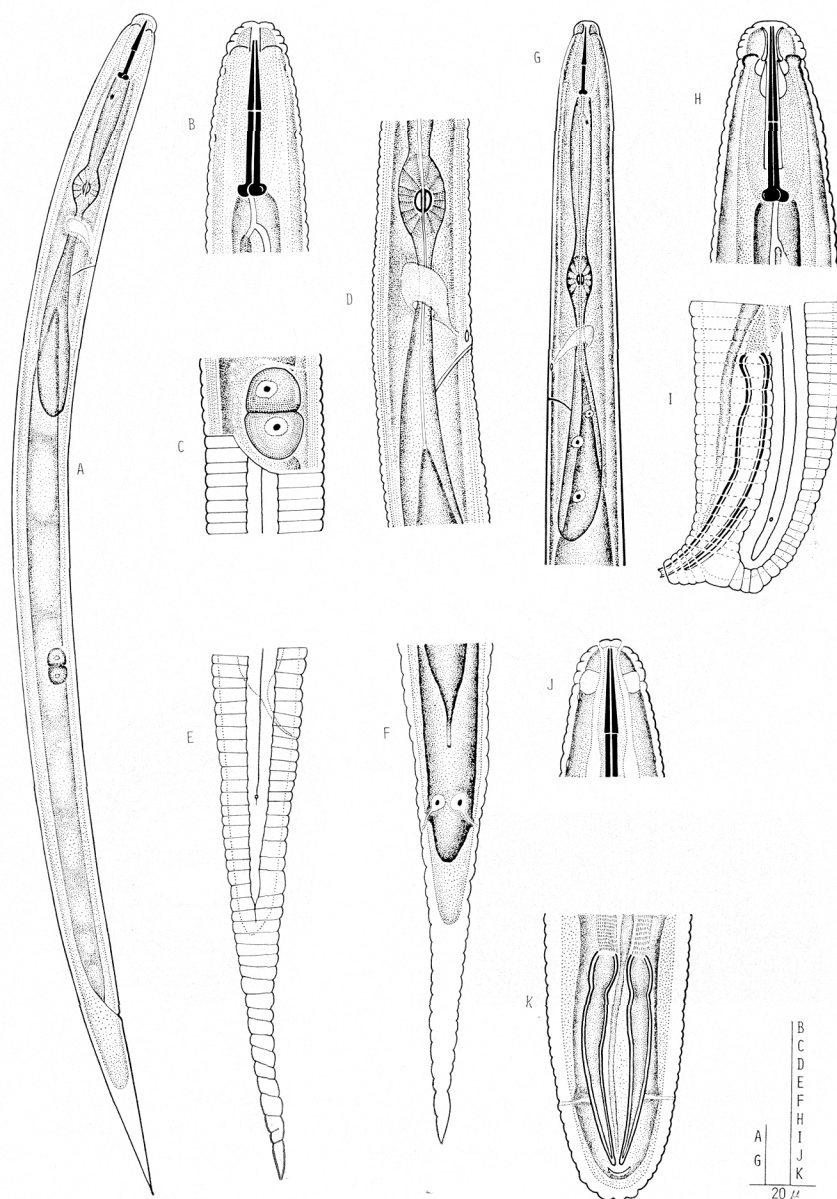


Fig. 1. *Heterodera elachista* n. sp. A-F: Second-stage larva, A: entire, B: head, C: gonadal primordium, D: posterior esophagus, E: tail, F: do., ventral, G-K: Male, G: anterior region, H: head, J: do., dorso-ventral, I: tail, K: do., ventral.

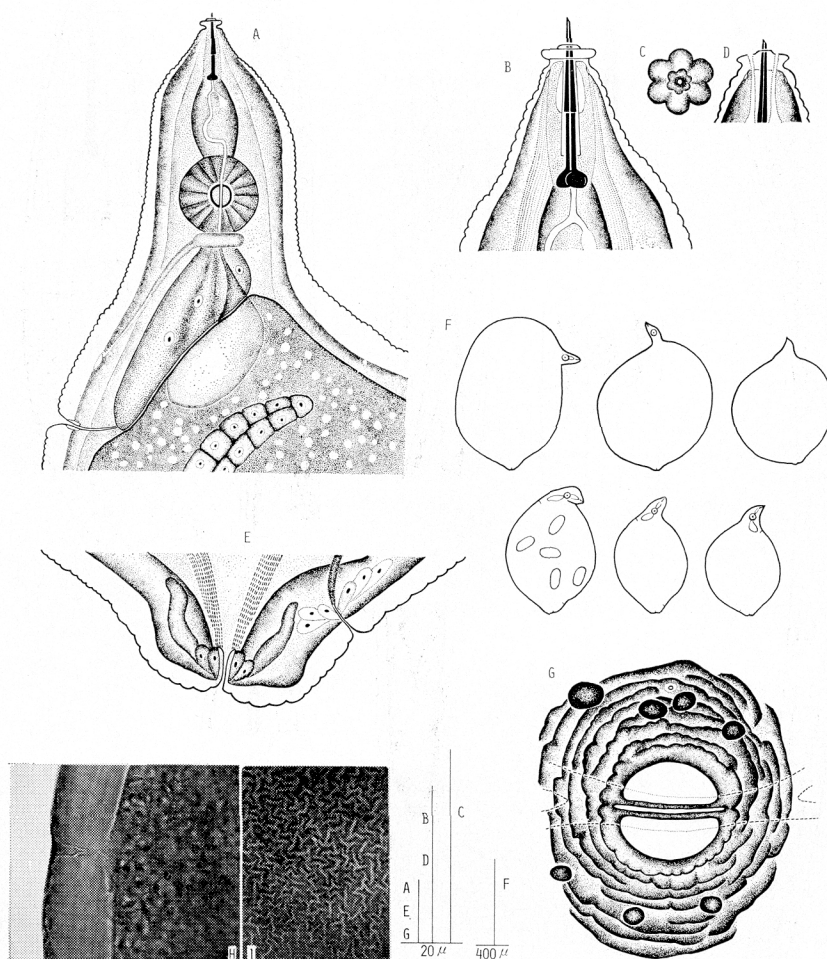


Fig. 2. *Heterodera elachista* n. sp. Female A: neck region, B: head, D: do., dorso-ventral, C: en face view, E: anal-vulval region, F: shape of female, G: cone top, H: excretory pore, sporozoa, I: cyst wall pattern.

esophageal bulb) : 8.2-10 (9.2), anterior end to end of esophageal glands (n=21) : 148-181 (161) μ , b' : 4.9-6.2 (5.3), anterior end to excretory pore (n=21) : 95-134 (120) μ , X (=distance of excretory pore from anterior end \times 100 / total body length) : 11.6-15.5 (14), stylet (n=21) : 20-21 (20.6) μ , opening of dorsal gland duct from stylet base (n=10) : 4-6 (4.9) μ , O : 19.5-26.2 (23.4), length of anterior part of stylet (n=10) : 10.5-11 μ , M : 50-52.5 (51.5), testis (n=20) : 300-480 (431) μ , T : 35-56.1 (50.3), spicule (n=16) : 26-29 (27.4) μ , gubernaculum (n=5) : 9-13 (11) μ .

Measurements of allotype male : L : 900 μ , breadth : 22 μ , head annules : 4, head height : 4.6 μ , head width : 8.5 μ , stylet length : 20 μ , stylet base to dorsal gland duct junction : 6 μ , head tip to junction of esophagus and intestine : 114 μ , head tip to end of esophageal gland : 172 μ , head tip to excretory pore : 131 μ , testis : 480 μ , spicule : 28 μ , gubernaculum : 11 μ , phasmid to tail tip : 12 μ .

Head hemispherical, 7.6-8.5 (8.2) μ (n=15) wide, 4.2-5 (4.6) μ (n=15) high, with four post-labial annules. Amphid openings small, seen only in dorso-ventral view between head cap and first annule. Anterior cephalids at position of 2nd to 4th body annule behind head, posterior ones at mid-stylet level. Well developed stylet with basal knobs sloping posteriorly. Four longitudinal incisures on lateral field; outer bands wider than inner ones, extending onto the tail, incontinuous around the tail tip. Anterior part of stylet about 15% of total stylet length. Dorsal esophageal gland duct 4-6 μ behind the stylet knobs. Median esophageal bulb slender, flattened with strong crescentic valve plates. Nerve ring broad and encircling the esophagus half-way between median bulb and intestine; esophageal-intestinal valve small and inconspicuous. Junction of esophagus and intestine near the excretory pore, at about 14% body length from the head. Hemizonid 2 annules long, situated 2 to 8 annules (n=5) anterior to excretory pore. The specimens

examined have a single testis which is uniformly packed with sperms. Cloaca with a small, raised circular lip. Two stout, arcuate spicules terminating a single pointed tip. Gubernaculum small, and trough-shaped. Phasmsids located 8 to 12 annules from tail tip. Hind part of body always twisted in dead specimens.

Differential diagnosis

By having lemon-shaped, bullate and ambifenestrate cysts, *Heterodera elachista* belongs in the *schachtii* group or "group 4" (Mulvey)⁴⁾. This species differs from all known species in the genus, except for *H. salixophila* Kirjanova, 1969, in shape and length of fenestra.²⁾ The fenestra shape resembles "guard cell", place round stoma in plant leaves. The stylet of females is shorter than that of *H. salixophila*, 19-24 μ against 33-40 μ , and the larval stylet is also shorter, 18 μ against 30 μ . This species resembles *H. oryzae*, *H. sacchari* Luc et Merny, 1963, and *H. leuceilyma* Di Edwardo et Perry, 1964, all of which have graminaceous host plants, in the morphology of the second stage larvae bearing 3 lateral lines, but differs from these three species in the slender underbridge without finger-like projections of cyst cone structure as described by Mulvey in 1972.⁴⁾ This species also characterized by a comparatively shorter stylet of female adult as well as the second stage larva. *H. elachista* differs from *H. oryzae* in the following characters, which are shown in Table 1.

Type host: rice (*Oryza sativa* L.).

Type locality: Konosu, Saitama, Japan.

Type slides

Holotype female on slide no. 73/10/1, deposited in the Nematology Collection of the Phytonemic Research Laboratory, Central Agricultural Experiment Station, Konosu, Saitama, Japan.

Paratypes (males, larvae, eggs, and cyst cones) on slide nos. 73/10/2-20, in the same collection.

I am grateful to K. Shimizu for giving

Table 1. Morphological comparisons of *Heterodera elachista* n. sp. with *H. oryzae*

	F. s.	f. l.	f. w.	V. s.	u. l.	u. w.	L. l.	L. t.	L. h.	E. l.
<i>H. oryzae</i>	28-30 ^{a)}	40-55 ^{b)}	32-45 ^{b)}	42-50 ^{b)}	110-150 ^{b)}	52-70 ^{b)}	370-507 ^{a)} (440)	67, 69 ^{a)}	35-45 ^{a)} (40)	90-120 ^{a)} (104)
<i>H. elachista</i>	19-23	25-37	25-45	30-43	75-90	8-12	330-405 (367)	44-57 (53)	26-36 (31)	78-102 (90)

F. s. : female stylet, f. l. : fenestra length, f. w. : fenestra width, V. s. : vulval slit, u. l. : underbridge length, u. w. : underbridge width, L. l. : larval length, L. t. : larval tail, L. h. : larval tail hyaline portion, E. l. : egg length.

a) : after Luc *et al.*,³⁾ b) : after Mulvey.⁴⁾

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和 文 摘 要

陸稲のシストセンチュウの新種, *Heterodera elachista*

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日本のイネのシストセンチュウは、岡田 (1953) の発見以来、東北から九州におよぶ広汎な分布が知られ、陸稲の連作障害の、また一部直播水稲の生育障害の原因として重要視されている。本種はアフリカ産イネ寄生種、*Heterodera oryzae* Luc *et* Brizuela, 1961と同一種とみなされてきたが、原記載および Mulvey の記述の線虫と比較した結果、種々の形質において合致しないことを知った。シストはレモン形で bullae があり、ambifenestra を持ち、*schachtii* グループに属する。しかし、fenestra は植物葉の孔辺細胞に似た特徴的な形をもつので *H. salixophila* Kirjanova, 1969 以外の種とは明らかに区別される。さらに *H. salixophila* と

は同種の雌と幼虫の口針が、それぞれ 33-40 μ と 30 μ であるのに対し本種のは 19-24 μ と 18 μ で短かく容易に区別できる。なお本種は *H. oryzae*, *H. sacchari* Luc *et* Merny, 1963 および *H. leuceilyma* Di Edwardo *et* Perry, 1964 とは幼虫の側線が 3 本であること、寄主がいずれもイネ科植物であるという点でそれぞれ近縁種と考えられるが、本種は fenestra の形、underidge が細いこと、finger-like projection を欠くこと、多くの形質が小形であるなどの点で明確に区別され、最も小さいという意味のギリシア語から *H. elachista* と命名し、新種として発表する。